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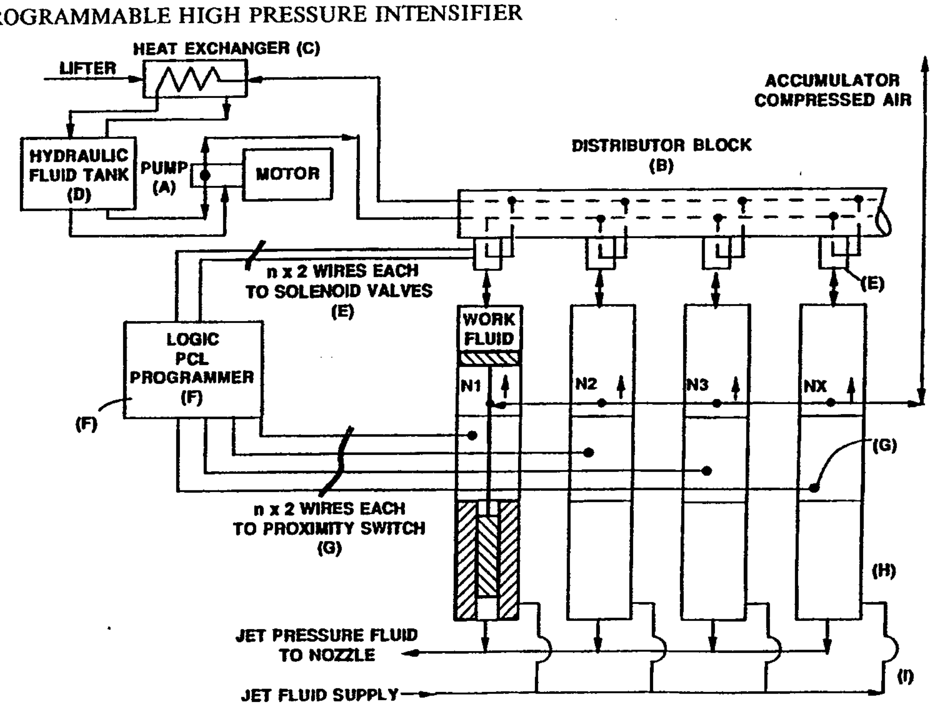

(57) Abstract

An electronic intensifier unit for producing a pressure intensified liquid jet comprising intensifier mechanism exhibiting individually controllable parameters, the intensifier unit being controlled by electronic controlling mechanism (F), the controlling mechanism being connected to electrically controllable valve mechanism (B) for the distribution of a working fluid to said intensifier mechanism.

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PROGRAMMABLE HIGH PRESSURE INTENSIFIER

FIELD OF INVENTION

The invention relates to programmable hydraulic intensifiers, and in particular to an electronically controlled apparatus for generating a pressure intensified jet which may be a continuous jet, a number of discrete pulses, or a single pulse.

BACKGROUND OF THE INVENTION

Within the prior art there exists a number of mechanical hydraulic Intensifiers for producing a high pressure jet in a fluid. Normally the operation of these units is based on a set ratio between the hydraulic working fluid and the fluid being intensified. Usually the intensification is accomplished by the ratio of the diameters of the working and intensifier pistons.

The aforementioned mechanical intensifiers provide a hydraulic working fluid at a first pressure fed into a working piston cylinder. These cylinders have a predetermined diameter. A second fluid, such as water, is fed into an intensifier cylinder of lesser diameter than the working piston cylinder. In operation the pressure of the working piston is transferred to the intensifier piston in the intensifier cylinder which is of smaller diameter than their working cylinder, and hence the pressure of the second fluid is intensified. Examples of intensifiers known in the art are as follows:

US4,690,622	US2,356,917	US4,465,438
US2,762,307	US4,607,792	US2,876,704
US2,807,215	US3,811,795	US3,811,798
US2,845,030	US3,133,503	US4,342,544
US2,935,952	US4,526,000	US4,583,921
US3,133,503	US4,836,613	US4,734,013
US3,314,367	US4,734,013	US4,714,411
US3,323,461	US4,514,149	US4,104,008
US4,286,927	US1,019,521	US1,993,230
US4,363,211	US2,243,978	US2,985,050
GB1,599,411	FR792,843	JP28,076

EP233,771 FR2,623,570 GB1,351,900
CA971,581 GB1,490,351

The pressure intensified fluid from the cylinders resulting from the action of the working pistons may be used directly to provide a jet. The resultant jet and the characteristics thereof will depend to a large degree on the fixed mechanical nature of the intensifier used. For example the resultant jet may be a series of pressure pulses resulting from the discrete strokes of an intensifier piston. To provide a continuous jet with such a mechanical unit the high pressure fluid can be charged into an accumulator as shown in U.S. patent 2,876,704. The accumulator can then be discharged, again usually to provide a jet that will appear essentially as a steady jet with minor pressure fluctuations.

Other methods to minimize pressure fluctuations and to avoid the use of the aforementioned accumulator, has been proposed in U.S. patents 4,690,622 and 4,734,013 where a plurality of intensifiers may be employed in a single packaged unit, the intensifiers thereof being cooperatively coupled together.

However those devices known in the prior art are mechanical contrivances having specific set inter-related operating parameters, such as length of stroke for the piston, number of strokes per period time, number of pistons, or the like. These parameters limit the range of operation for any specific model. Moreover, the mechanical linking of a plurality of intensifier cylinders and pistons as a cooperative unit brings about a major disadvantage. Should any one piston, valve, seal or other component of the assembly fail, the effectiveness in operation of the other linked components of the assembly will be negatively affected, eventually resulting in a complete failure of the intensifier cooperative assembly. Further the control of the operation of these units is provided with a complex mechanical device which has set repeatable functions with no ability to vary the sequence or type of control offered.

Nowhere within the prior art is there found an

electronically controlled intensifier unit, which may be programmable, which negates the limitations of mechanical units found in the prior art as described above. Specifically such a unit being programmable allows the same standard unit to be used in a number of applications to provide a single pulse jet, a discrete pulse train jet, or a continuous jet. Within the prior art specific applications frequently require specifically designed units. For example it is not practical with the prior art units to provide a standard unit which might be used for repairing spalled concrete requiring a discrete pulse train jet, for fine cutting requiring a continuous high pressure jet, or for forming a hole requiring a single pulse. The present invention allows for these variations in operation simply and effectively with the same unit.

It is therefore a primary object of the invention to provide an electronic intensifying unit that obviates the limitations of the mechanical intensifier units found in the prior art.

It is a further object of the invention to provide an electronically controlled intensifying unit which provides for the flexible control and operation of the unit as required by the specific application.

Further and other objects of the invention will become apparent to a man skilled in the art when considering the following summary of the invention and the more detailed description of the preferred embodiments illustrated herein.

SUMMARY OF THE INVENTION

According to one aspect of the invention there is provided an electronic intensifier unit for producing a pressure intensified liquid jet comprising intensifier means (preferably cylinders and working pistons being independently operable) exhibiting individually controllable parameters, the intensifier unit being controlled by electronic controlling means (such as a solid state logic programmable device or microprocessor) the controlling means being connected to electrically controllable valve means (such as individual

solenoid valve means) for the distribution of a working fluid to said intensifier means, preferably the electronic controlling means being programmable to control the characteristics exhibited by the intensifier means (for example the amount of displacement achieved per cycle, the frequency of the cycles, the sequence of the intensifier means, the overlap or underlap of each cycle relative to a fixed electronic feedback point with the cycle, or simply in time, measured relative to each other, or if a piston is present, the amount of displacement achieved per stroke, the number of strokes per unit of time, the sequence for operating any one piston relative to the other, and the over, or underlap of each stroke relative to a fixed electronic feedback point along its path, or simply in time, measured relative to each other, preferably for the overlap condition there is always at least two components with the intensifier means engaged in a work cycle or if a piston is present engaged in a downward stroke, before the first component has reached the end of its pressure cycle or if present a piston has reached the end of its downward stroke.

According to yet another aspect of the invention there is provided an intensifier for producing a pressure intensified liquid jet comprising: a plurality of working cylinders and working piston means; a plurality of intensifier cylinders and intensifier piston means, said intensifier piston means being entirely separate with respect to fluid handling from said working piston means, but mechanically linked with respect to said working piston means; a plurality of electrically controlled distribution valve means (and preferably solenoid valves) for distributing a working fluid to each of said working cylinders through connecting means (such as a fixed or flexible conduit), said distribution valve means having a working fluid inlet and a return; said distribution valve means being electrically connected to and controlled (for example timed) by a logic controlling means (preferably solid state), such control, such as time, may be sequential such that the position of any one first working

piston will not have reached the end of its working downward stroke relative to at least a second piston engaged in a downward working stroke, may be timed such that a plurality of working pistons are engaged in downward working strokes; in one embodiment said logic controlling means receiving an electronic position feedback from a sensing means such as a proximity switch, activated by any one of said working piston means; (preferably said logic controlling means receiving an electronic feedback of its set timing sequence if the pistons are sequenced (output); said timing sequence to be verified against (input), with automated feedback to a machine operator for corrective action); valve means connected to said intensifier cylinders for admitting a jet fluid at a first pressure, and for discharging said jet fluid at an elevated second pressure in response to reciprocation of said intensifier piston means in said intensifier cylinders; and (preferably gas loaded) biassing means in communication with said working pistons, operative to urge said working piston means into said working cylinders, said pistons being independent in operation with respect to one another and being free of restriction other than said biassing means; operation of said working piston means causing respectively said intensifier piston means to move into the respective intensifier cylinders; supplying jet fluid to said intensifier cylinders, at a first pressure through first valve means; discharging said jet fluid from said intensifier chambers at a second elevated pressure through second valve means; preferably discharging said elevated pressure jet fluid in a common conduit, and preferably discharging same from jet nozzle means; as required by the application of the intensifier said jet fluid may exhibit minor pressure fluctuations, and for other applications preferably none at all, or a plurality of pressure valleys.

According to yet another aspect of the invention there is provided an intensifier for producing an intensified pressure liquid jet comprising a plurality of individually spaced working cylinders and pistons, having a first

diameter, a plurality of intensifier cylinders and pistons having a second diameter less than said first diameter, the intensifier to intensify the pressure from said working pistons to said intensifier pistons; electronic control means, and preferably solid state control means such as a microprocessor, for controlling individually operable electrically controllable distribution valves, and preferably solenoid distribution valves, for the distribution of a working fluid to said working cylinders, the electrically controllable distribution valves and preferably the solenoid distribution valves being connected to a working fluid inlet and a working fluid return means to cause said valves to alternate, preferably the electronic control means for receiving a signal (in one example receiving a timed signal) preferably the signal being received from sensing means and preferably a proximity switch activated by said working first piston, in one embodiment the signal activating at least a second piston on a downward stroke before the first piston has reached the end of its downward stroke; valve means in communication with said intensifier cylinders for admitting a jet fluid at a first pressure, and for discharging said fluid at an intensified pressure in response to reciprocation of said intensifier pistons in said intensifier cylinders, and self returning (preferably gas loaded) biassing means in communication with said working pistons operative to urge said working pistons into said working cylinders, said pistons being independently operable with with respect to one another and being free of restrictions other than said biassing means.

In a preferred embodiment there is provided a clear mechanical separation between the working cylinder and fluid and the piston of the jet fluid, thus avoiding the problems associated with accidental mixing of the two incompatible fluids. (a prerequisite for FDA approval). The required shaft seals are provided to seal the working fluid in relation to the working fluid piston rod and the intensified fluid in relation to the intensified fluid piston rod and further to provide a seal whereat the two pistons

interconnect to ensure the integrity of the working fluid. Any known sealing methods or devices of sealing the shafts would suffice in this regard as long as the objectives of a clear mechanical separation as discussed above are achieved.

A further advantage of the invention is, that in the event of impending failure of one of the components, or failure of any one unit comprising the complete assembly, the unit may perform a self diagnostic analysis (for example input vs. output), thus being able to identify the"missing" unit suspect of impending failure. The machine operator can thus be alerted to take corrective action before complete failure occurs, and the "missing" unit can be replaced on a preventative maintenance basis.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be illustrated with respect to the following drawings illustrating embodiments of the invention in which:

Figure 1 is a block diagram of the intensifier illustrated in a preferred embodiment of the invention.

Figure 2 is a perspective view of a single intensifier unit illustrated in a preferred embodiment of the invention.

Figure 3 is a longitudinal cross sectional view of the single intensifier unit of FIG 2.

Figure 3A-3C are cross sectional views of the single intensifier unit of FIG 2 at lines A-A , B-B, and C-C respectively.

Figure 4 is a schematic sectional view of the valve 60 of figure 3.

Figure 4A is a sectional view of the valve 60 of figure 4 in the line A-A.

Figure 5 are Basic Hardware and Software Block Diagrams.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

As shown in the figure 1, the intensifier system can be constructed from a plurality of (minimum of two)

identical independently operable units, (N1, N2, N3, Nx) whose housings are fastened in any suitable position with respect to one another depending on the application and proposed system use. For example the system illustrated in figure 1 might be embodied in a single unit as seen in figure 2 or in a system of separate components for large installations. Hydraulic fluid under pressure is generated by pump (A) and admitted to a distributor block (B) through a central bore (b) leading to a centrally located inlet port (c) of spaced, individual three way solenoid valves (E)x, of a multitude x equal to the number of operable units Nx.

Adjacent to each valve housing is an outlet port (d) for releasing hydraulic fluid to flexible conduits for admitting hydraulic fluid under pressure to the first port (e) of the intensifiers Nx and for discharge of the return fluid through the same flexible to valve outlet port(f) then to a suitable heat exchanger (C) and reservoir (D) to dissipate heat as is known in the art.

Solenoid valves (Ex) are connected by electric wiring to a logic programming unit (F), which is connected to x proximity switches (Gx) by electric wiring. Valves (Hx) as best seen in figure 4 are connected to the Nx intensifiers for admitting a jet fluid at a first pressure, and for discharging (I) said jet fluid at an elevated second pressure. Compressed air is provided to bias the intensifiers Nx at inlet port (K) in communication with said working pistons, operative to urge said working pistons into said working cylinders, said pistons being independently operable with respect to one another and being free of restriction other than said compressed air biassing at K.

The logic programming unit F is a programmable controller which responds to input information from the system in a manner known in the art. Any units such as those manufactured by Siemens or other suppliers comparable to the Allen Bradley SLC 500 used in the paper industry would be quite acceptable. Of course other controllers may prove equally acceptable. The controller should be programmable to

achieve many of the advantages of the invention and able to interface with an operator for changes in instruction and both receive information and send instructions for example to the solenoids at programmed intervals to operate the intensifier with the desired jet characteristics.

Referring to figures 2 and 3 there is illustrated in perspective and in cross section side plan view an intensifier unit which is a single apparatus designed to provide all of the components of the intensifier in a single inline package. The unit of figures 2 and 3 works identically to the description in relation to figure 1. Therefore there is provided an inline intensifier unit 10 including a working cylinder 20 mounted with a frame 15. The working cylinder 20 includes an inlet and outlet for the hydraulic oil at 25 and an air pressure return port 22 which may be attached to the accumulator of figure 1. In line with the working piston 29 is an intensifier piston 38 (attached to piston rod 38.) A holder 39 is provided to connect the piston 29 of the cylinder 20 with the piston 38 of the cylinder 30. Connection may be made by conventional methods. Seals s1(hydraulic seal) and s2 (jet fluid seal) are provided to properly seal the piston rods against the respective fluids. The intensifier unit 10 operates independently from any other unit by the operation of the solenoid Ex of figure 1 by the controller F at the correct time. The solenoid Ex therefore controls the flow and duration of flow of the working fluid to the piston 29 via opening 25. The hydraulic fluid therefore drives the piston 29 in cylinder 20 towards the intensifying cylinder 30. This action causes the intensifying end to accumulate water in the passage 39 wherein the water will be subjected to the intensifying force. The diameter of the working cylinder is 2.5 inches. The diameter of the intensifying cylinder is .625 inches. Therefore the pressure of the hydraulic fluid may be intensified by a ratio of 16:1 in this embodiment. The water therefore exits the outlet 48 for a predetermined period of time. The operation and description of the inlet/outlet valve 60 will be described hereinafter. The centre piece 30 of the

unit 10 includes a proximity switch 35 which provides the controller F with a signal as to the location of the intensifying piston over its stroke. This information is provided to coordinate the cycle of another unit as the application requires. For example if a continuous jet is required its is important that another intensifier unit begin its operation prior to the end of the stroke of a first unit. The output of these units would then present a continuous jet of intensified water by correctly timing the position of the cylinders with respect to one another through the controller.

The barrel 40 wherein the intensifying passage 39 is provided is attached by bolts 36 as is known to the centre piece 30 wherein the intensifying piston rod 38 travels. Also the head 50 is attached via bolts 41 to the barrel 40 in like manner. Similarly the cylinder 20 within which the working piston 29 travels is attached to the barrel.

Referring now to figures 4 and 4A there is provided a schematic sectional view of the valve 60 of figure 3. The valve 60 is disposed near the head 50 of the unit 10 and provides a mechanism to control the flow of the water being intensified and the separation of the high and low pressure sides. The valve 60 therefor is similar to a ball valve in construction in that passage ways are provided for the low pressure flow and the high pressure flow. The valve 60 therefor includes a body 67 made from metal or ceramics. The body 67 includes an end 60b and an end 60c. The ends 60b and 60c have openings 61b and 61c therein wherein checking devices 65 and 63 are provided. Each checking device 63 and 65 includes a ball 63a and 65a biased by a spring 62 or 65b and retained by a holder 61 or 65c disposed in a annular seat. Each ball 63a and 65a provides a one way checking device that allows flow in opposite directions which will be described hereinafter. The body of the valve 60 includes a seat 68a for the seal 68 which is an O ring . The body also includes a waterway 69 which allows access of the water to all three low pressure inlets 64 as best seen in figure 4A.

As the water enters the low pressure inlet 60a it

will travel around the waterway 69 to the three low pressure inlets 64 on opposite sides of the valve. The checking mechanism 65 disposed near the end 60b of the valve 60 will allow the water to pass to chamber 39 as the water flow forces the ball 65a to move towards end 60b of the valve 60. Water will therefore enter chamber 39 and be compressed by the stroke of the piston 38 as best seen in figure 3 the check mechanism 65 preventing low pressure water from entering chamber 39 during each intensifying stroke. The high pressure water unable to pass through check 65 will exit through ports 66 which are provided on opposite sides of the valve 60 as best seen in figure 4A. A waterway 69a is provided to allow access to all three ports 66. The intensified water therefore will pass to the check mechanism 63 which allows the water to exit therefrom as the ball 63a is moved by the force of water to allow the intensified water to exit through outlet 48a.

The valve body 67 includes abutting portions P1 and P2 which engage rounded edges at 50a1 and 40a1 in the chamber provided in which valve 60 is disposed thereby improving the separation of the low and high pressure sides of the valve. The balls 63a and 65a in the preferred embodiment are ceramic but may be of any suitable material. The ball 63a may be smaller than the ball 65a (ie 3/16 : 4/16).

The following list (referring to Fig. 5) therefor represents a selection of equipment used to construct the units presented in the figures:

1. High pressure inline two way valve 60 made to specification.
2. Hydraulic pump A supplied by Vickers PVB series pumps pressure compensated.
3. Working Cylinder 20 2.5 inch diameter Vickers
4. Vickers distributor block B
5. Three way Solenoid Valves Ex Vickers Modular valves with fast response ie 4 times per second.
6. Flexible connectors dx hydraulic hose correctly rated.
7. Allen Bradley SLC 500 PLC or comparable

controller.

Referring now to the drawings when a jet of water is desired the hydraulic fluid is pumped into the working cylinder 20 under a known pressure depending on the application. The hydraulic fluid is pumped via pump A at for example 6,000 psi. The controller F therefore allows the hydraulic fluid to enter the opening 25 via solenoids E for a predetermined period and stroke of the working piston 29 at which time the controller closes the solenoid E thus ending the stroke. At the same time as the stroke of the working piston 29 the intensifier piston 38 coupled to piston 29 is driven to intensify the water disposed in chamber 39 and thereby provide an intensified pressure of 24,000 psi in the water because of the 16:1 ratio in this embodiment in the diameters of the piston faces 29 and 38. The valve 60 allows for the separation of the low and high pressure sides of the water flow as described above. The air port 22 for unit 10 or Kx for units Nx provide constant biasing of the working piston 29 to its initial position prior to beginning a stroke. An air accumulator as labelled in Figure 1 is provided for this biasing function. Any practical know biasing method however would suffice. Therefore once the solenoid E is closed then the working piston 29 will return to its initial position.

When a plurality of units 10 or N are provide with an installation the proximity switches G provide information to the controller F as to the location of each unit 10 or N in its stroke. The controller therefore can control the sequence of the units 10 or N and the stroke of each for the required application.

For example if it is desired to have a continuous jet then its is recommended that three units 10, N1, N2 and N3 be provided. Therefore the controller F allows the solenoid E1 to open allowing hydraulic fluid into intensifier unit N1. When the unit N1 is 60% complete with its working stroke, as demonstrated by the signal from the proximity switch G1 to the controller F, the controller will allow the solenoid E2 to open providing a working stroke of intensifier unit N2

overlapping for 40% of the stroke of unit N1. The controller will then hold both N1 and N2 open, in order that N1 can complete its stroke, and then PLC will open E1 to allow N1 to return to its initial position, as biased by the accumulator and the 100 psi air provided at opening 22, in time to be available for the next stroke when unit N2 reaches 60% of its stroke. Therefore a continuous intensified jet is provided. As with any operation in time by monitoring (not shown) the inlet and outlet pressures of each unit or any other convenient parameter the controller may determine that unit N2 is in need of maintenance. Solenoid E1 would therefore no longer open but solenoid E3 would open as allowed by the controller F bringing unit N3 on line until such time as unit N1 is repaired. A message to the operator may be provided via a console or CRT. In this manner the continuous jet is not interfered with, yet maintenance may be provided as convenient. A discrete pulse train application may be provided in a similar manner with the same unit by the controller F delaying the operation of solenoid E2 until unit N1 has completed its full stroke. Further the controller F could allow two units N to operate simultaneously and provide a ultra high pressure at increased flow capacity. The controller F would therefore allow units N1 and N2 to operate at the same time by signalling the opening of solenoids E1 and E2.

The controller F as best seen in Figure 5 therefore as is apparent from the aforementioned example may be used to vary the operation of a standard unit and thus, provide a continuous jet for cutting paper in paper mills, provide a pulse train for renovating spalled concrete or provide a single pulse for punching an opening through various materials. The controller may therefore provide:

1. The opening and closing of each solenoid.
2. The sequence of working piston operation.
3. The overlap or underlap of piston strokes.
4. The length of the stroke for each working piston.

5. The pressure of the resulting intensified jet.
6. The online maintenance of the respective intensifier unit.
7. Data logging and performance information for the system.
8. Failure identification and operator warnings.

The block diagram of Figure 5 illustrates the sequence of events in functional form for both the hardware and software, to illustrate one example of the functional interrelationship that can be established in using the present invention.

Therefore it may be understood by those skilled in the art the advantages obtainable by the use of the invention by an operator. It will no longer be necessary to provide a number of specifically designed units for alternate applications. The operator may by varying the program only without hardware changes to obtain a unit which performs in various modes of operation examples of which having been described above. This is very convenient to the operator who with the same unit is no longer limited to either sequential or simultaneous operation as those units found in the art but may accomplish both tasks at will even setting out patterns which mix various modes, for example pulse trains for a period, continuous jets for a period and single discrete pulses for a period. The advantages of a preventive maintenance program set out above and the available warnings also enhance the value of the system to operators.

While the invention has been described in connection with specific embodiment thereof, it is to be clearly understood that this is done only by way of example and not as a limitation to the scope of our invention as set forth in the objects thereof and in the appended claims.

As many changes can be made to the various embodiments of the invention without departing from the scope of the invention; it is intended that all material contained herein by interpreted as illustrative of the invention and not in a limiting sense.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE AS FOLLOWS:

1. An electronic intensifier unit for producing a pressure intensified liquid jet comprising intensifier means exhibiting individually controllable parameters, the intensifier unit being controlled by electronic controlling means, the controlling means being connected to electrically controllable valve means for the distribution of a working fluid to said intensifier means.

2. The intensifier unit of Claim 1 wherein said intensifier means is cylinders and working pistons being independently operable.

3. The intensifier unit of Claim 1 or 2 wherein said electronic controlling means is a solid state logic device or microprocessor.

4. The intensifier unit of Claim 1 or 2 wherein said electrically controllable valve means are individual solenoid valve means.

5. The intensifier unit of Claim 3 wherein said electrically controllable valve means are individual solenoid valve means.

6. The intensifier unit of Claim 1 wherein the electronic controlling means is programmable to control the characteristics exhibited by the intensifier means (for example the amount of displacement achieved per cycle, the frequency of the cycles, the sequence of the intensifier means , the overlap or underlap of each cycle relative to a fixed electronic feedback point with the cycle, or simply in time, measured relative to each other, for the overlap condition there always being at least two components with the intensifier means engaged in a work cycle before the

first component has reached the end of its pressure cycle)

7. The intensifier unit of Claim 3 wherein the electronic controlling means is programmable to control the characteristics exhibited by the intensifier means (for example the amount of displacement achieved per cycle, the frequency of the cycles, the sequence of the intensifier means, the overlap or underlap of each cycle relative to a fixed electronic feedback point with the cycle, or simply in time, measured relative to each other, for the overlap condition there always being at least two components with the intensifier means engaged in a work cycle before the first component has reached the end of its pressure cycle)

8. The intensifier unit of Claim 2 wherein the electronic controlling means is programmable to control the characteristics exhibited by the intensifier means; (for example the amount of displacement achieved per stroke, the number of strokes per unit of time, the sequence for operating any one piston relative to the other, and the overlap, or underlap of each stroke relative to a fixed electronic feedback point along its path or simply in time measured relative to each other, the period engaged in a downward stroke, or the point a piston has reached the end of its downward stroke.)

9. An intensifier for producing a pressure intensified liquid jet comprising a plurality of working cylinders and working piston means; a plurality of intensifier cylinders and intensifier piston means, said intensifier piston means being entirely separate with respect to fluid handling from said working piston means, but mechanically linked with respect to said working piston means; a plurality of electrically controlled distribution valve means for distributing a working fluid to each of said working cylinders through connecting means, said distribution valve means having a working fluid inlet and a return; said distribution valve

means being electrically connected to and controlled by a logic controlling means, valve means connected to said intensifier cylinders for admitting a jet fluid at a first pressure, and for discharging said jet fluid at an elevated second pressure in response to reciprocation of said intensifier piston means in said intensifier cylinders; and biassing means in communication with said working pistons operative to urge said working piston means into said working cylinders, said pistons being independent in operation with respect to one another and being free of restriction other than said biassing means; operation of said working piston means causing respectively said intensifier piston means to move into the respective intensifier cylinders; supplying jet fluid to said intensifier cylinders at a first pressure through first valve means; discharging said jet fluid from said intensifier chambers at a second elevated pressure through second valve means.

10. The intensifier of Claim 9 wherein the control of the logic controlling means may be sequential such that the position of any one first working piston will not have reached the end of its working downward stroke relative to at least a second piston engaged in a downward working stroke, or may be timed such that a plurality of working pistons are engaged in downward working strokes.

11. The intensifier of Claim 9 or 10 wherein the distribution valve means are solenoid valves.

12. The intensifier of Claim 9 wherein said logic controlling means receives an electronic position feedback from a sensing means such as a proximity switch, activated by any one of said working piston means.

13. The intensifier of Claim 9 wherein said logic controlling means receives an electronic feedback of its set timing sequence when the pistons are sequenced, said timing

sequence to be verified with automated feedback to a machine operator for corrective action.

14. The intensifier of Claim 9 wherein said intensifier discharges said elevated pressure jet fluid in a common conduit, and preferably discharges said elevated pressure jet fluid from jet nozzle means.

15. The intensifier of Claim 9 wherein as required by the application said jet fluid may exhibit minor pressure fluctuations, and for other applications preferably none at all, or a plurality of pressure valleys.

16. *An intensifier for producing an intensified pressure* liquid jet comprising a plurality of individually spaced working cylinders and pistons, having a first diameter, a plurality of intensifier cylinders and pistons having a second diameter less than said first diameter, the intensifier to intensify the pressure from said working pistons to said intensifier pistons; electronic control means, for controlling individually operable electrically controllable distribution valves,for the distribution of a working fluid to said working cylinders, the electrically controllable distribution valves being connected to a working fluid inlet and a working fluid return means to cause said valves to alternate, valve means in communication with said intensifier cylinders for admitting a jet fluid at a first pressure, and for discharging said fluid at an intensified pressure in response to reciprocation of said intensifier pistons in said intensifier cylinders, and self returning biassing means in communication with said working pistons operative to urge said working pistons into said working cylinders, said pistons being independently operable with with respect to one another and being free of restrictions other than said biassing means.

17. The intensifier of Claim 16 wherein the electronic control means is a solid state control means such as a

microprocessor.

18. The intensifier of Claim 16 or 17 wherein the electrically controllable distribution valves are solenoid distribution valves.

19. The intensifier of Claim 16 or 17 wherein the electronic control means receives a signal (in one example receiving a timed signal) the signal being received from sensing means activated by said working first piston.

20. The intensifier of Claim 19 wherein the sensing means is a proximity switch.

21. The intensifier of Claim 19 wherein the signal activates at least a second piston on a downward stroke before the first piston has reached the end of its downward stroke.

22. The intensifier of Claim 20 wherein the signal activates at least a second piston on a downward stroke before the first piston has reached the end of its downward stroke.

23. The intensifier of Claim 19 wherein there is provided a clear mechanical separation between the working cylinder and fluid and the piston of the jet fluid, thus avoiding the problems associated with accidental mixing of the two incompatible fluids.

24. The intensifier of Claim 23 wherein shaft seals are provided to seal the working fluid in relation to the working fluid piston rod and the intensified fluid in relation to the intensified fluid piston rod and further to provide a seal whereat the two pistons interconnect to ensure the integrity of the working fluid.

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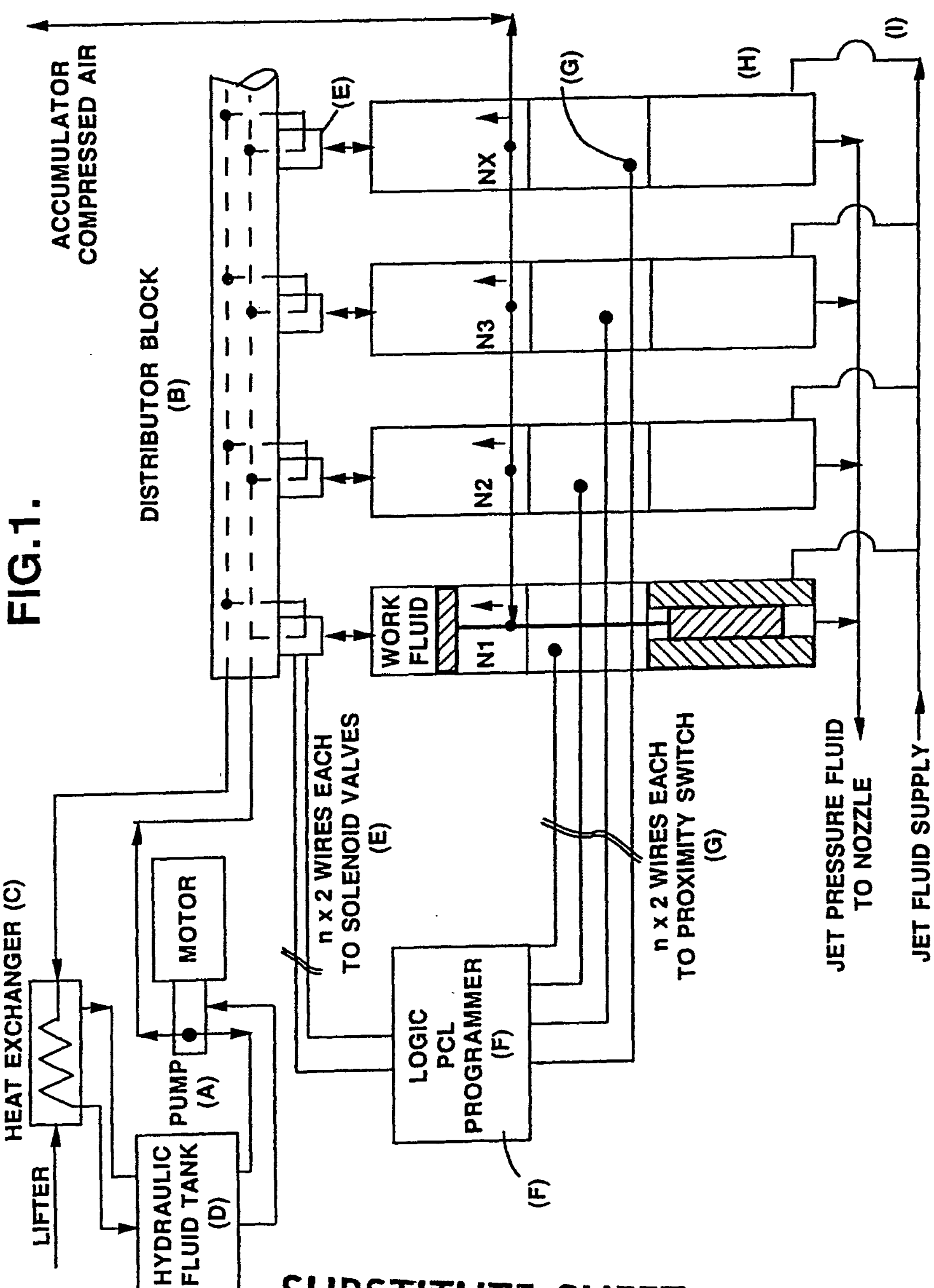

FIG.1.

SUBSTITUTE SHEET

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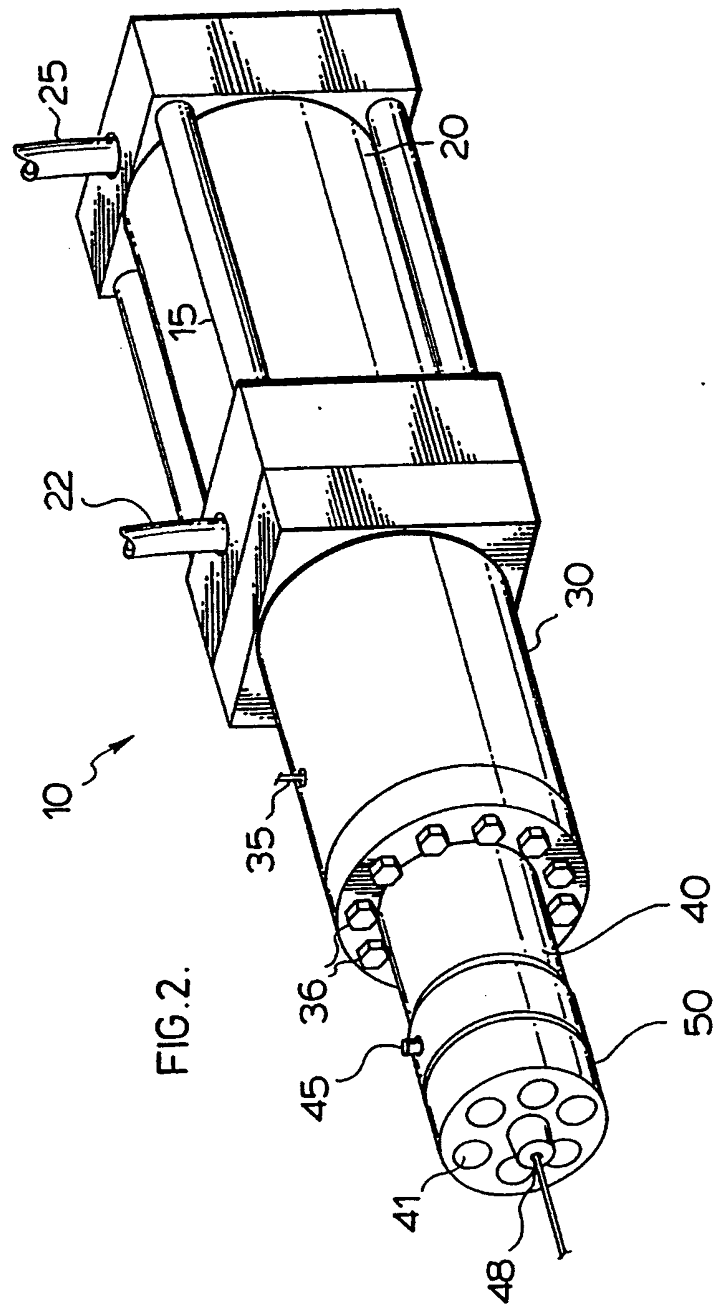

FIG.2.

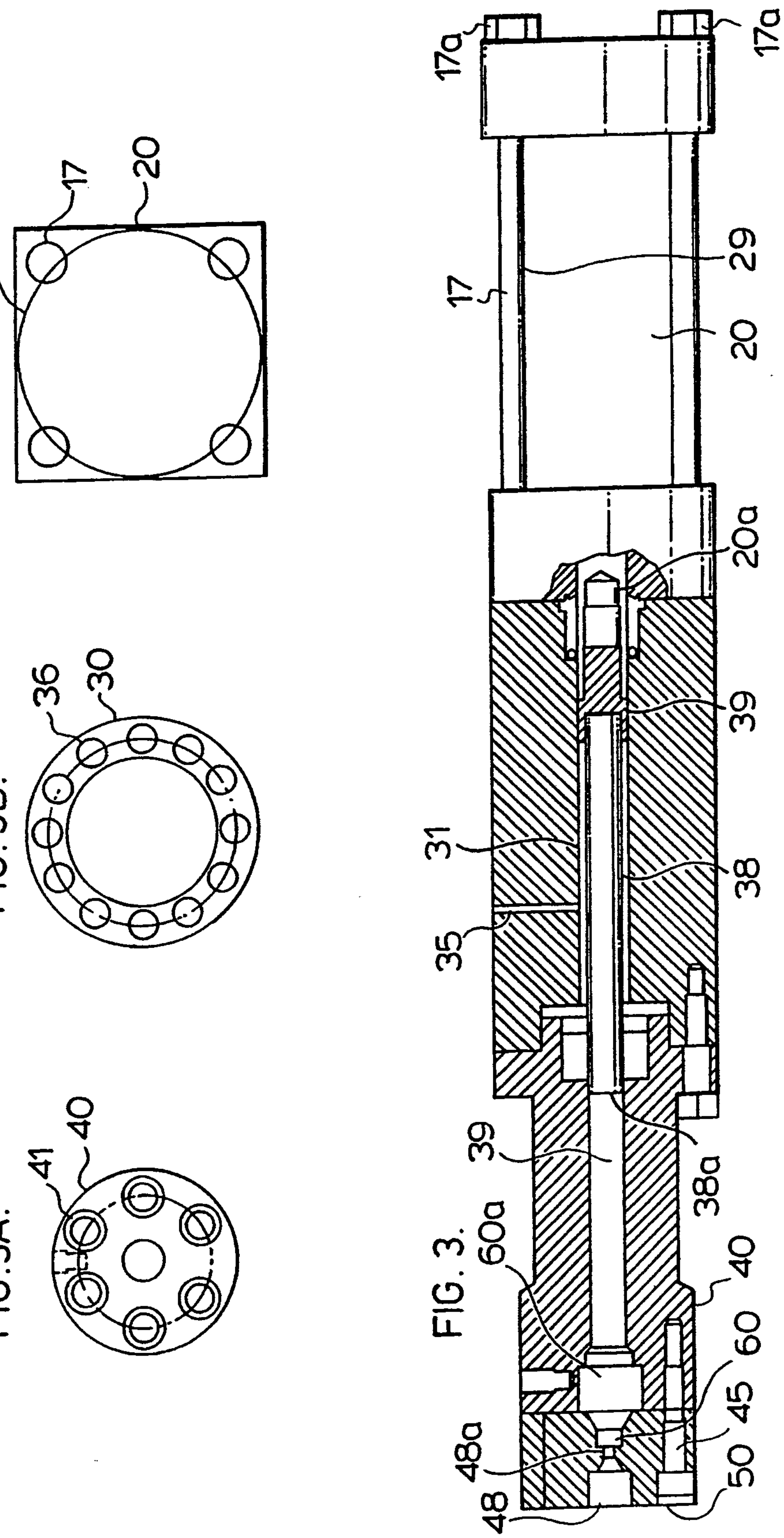

FIG. 3C.

FIG. 3B.

FIG. 3A.

FIG. 3.

SUBSTITUTE SHEET

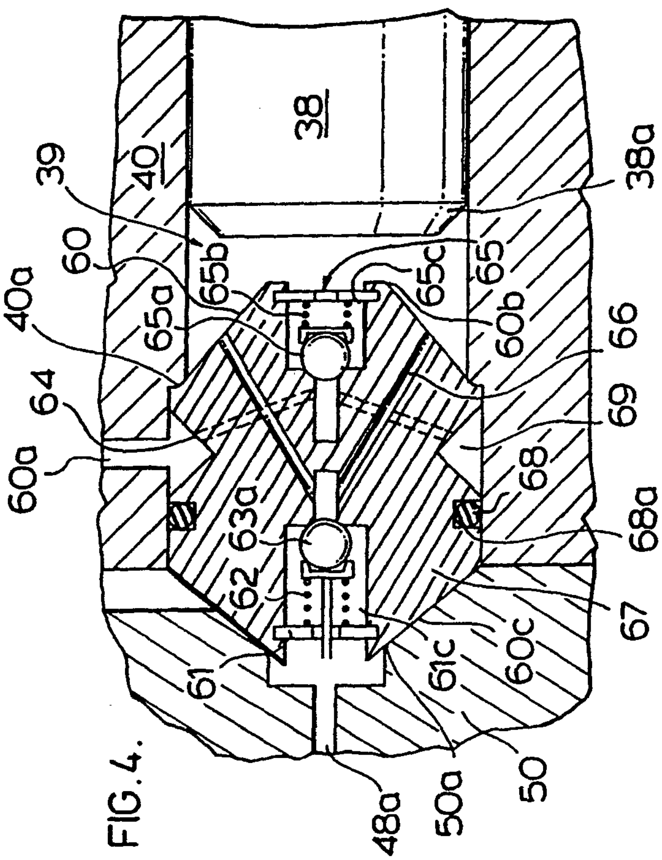

FIG. 4.

SUBSTITUTE SHEET

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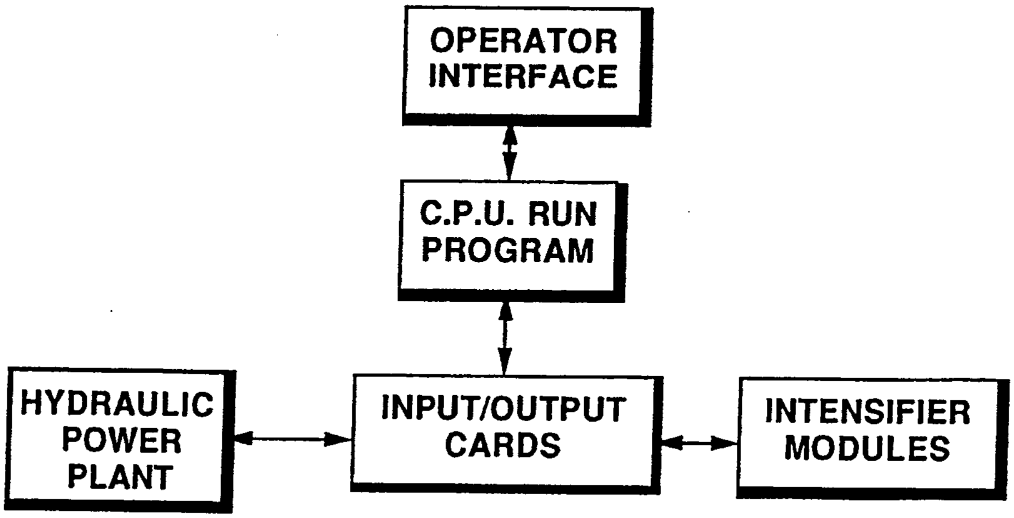

FIG.5a.

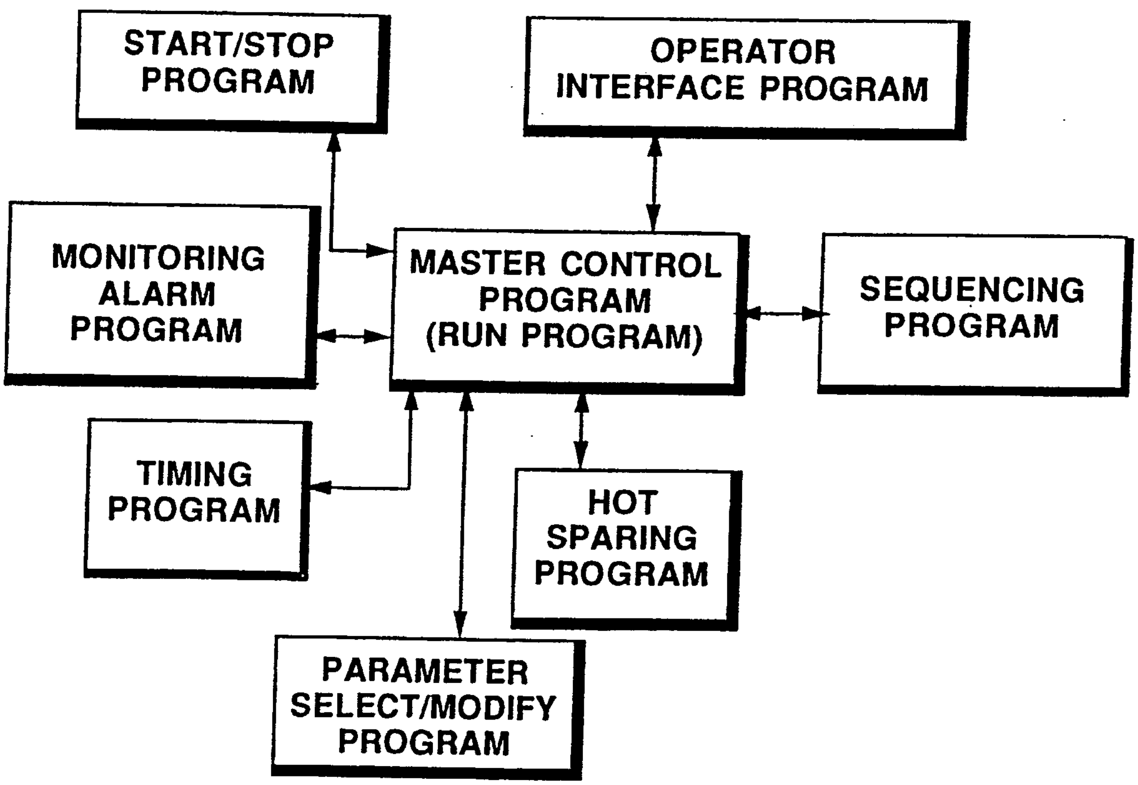

FIG.5B.

INTERNATIONAL SEARCH REPORT

International Application No PCT/CA 92/00252

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 F04B9/10; F04B49/06; F04B11/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	F04B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	US,A,4 527 954 (HALLIBURTON COMPANY) 9 July 1985	1-15
Y	see the whole document	16-24
X	US,A,3 234 882 (DOUGLAS) 15 February 1966	1,2,4
Y	see the whole document	16-24

° Special categories of cited documents :[10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
12 OCTOBER 1992	29. 10. 92
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	VON ARX H.P.

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. CA 9200252 SA 60224

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 12/10/92
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-4527954	09-07-85	None	
US-A-3234882		None	

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82